Development and Characterization of a Variable Aperture Attenuation Meter for the Determination of the Small Angle Volume Scattering Function and System Attenuation Coefficient

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LONG-TERM GOAL

In an effort to characterize the Volume Scattering Function ($\beta(\theta)$) in water, WET Labs undertook development of two instruments which can determine and characterize $\beta(\theta)$ in the near forward and wide angles. The Intermediate and Large Angle Scatter Sensor (ILASS) was developed to provide characterization of $\beta(\theta)$ at large forward angles and in the backward direction. This instrument is described in a separate report. The Variable Aperture Beam Attenuation Meter (VABAM) characterizes the $\beta(\theta)$ in the near forward direction. Work is nearing completion for this instrument.

SCIENTIFIC OBJECTIVES

The purpose of this project was to develop a sensor capable of determining appropriate attenuation coefficients to match with specific radiance measurement applications. Furthermore, the instrument will yield information about the shape of the near-forward volume scattering function. These measurements will be obtained with high spectral resolution throughout the visible part of the spectrum. The resultant instrument will be rugged enough to provide quality data for *in situ* field deployments.

WORK COMPLETED

Having completed fabrication and testing of a bench top prototype efforts focused upon developing an instrument for *in situ* use. These efforts are now complete and the instrument is now undergoing fabrication. In addition we are constructing an ILASS unit to be incorporated with the VABAM in a single acquisition package.

RESULTS

The attached figure shows a schematic representation of the field deployable VABAM. The unit consists of primary transmitter and receiver assemblies separated by a unistrut spacer defining the water volume. Source and receiver optics and the instrument electronics are housed in pressure cans at the respective ends of the unit.

Report Documentation Page

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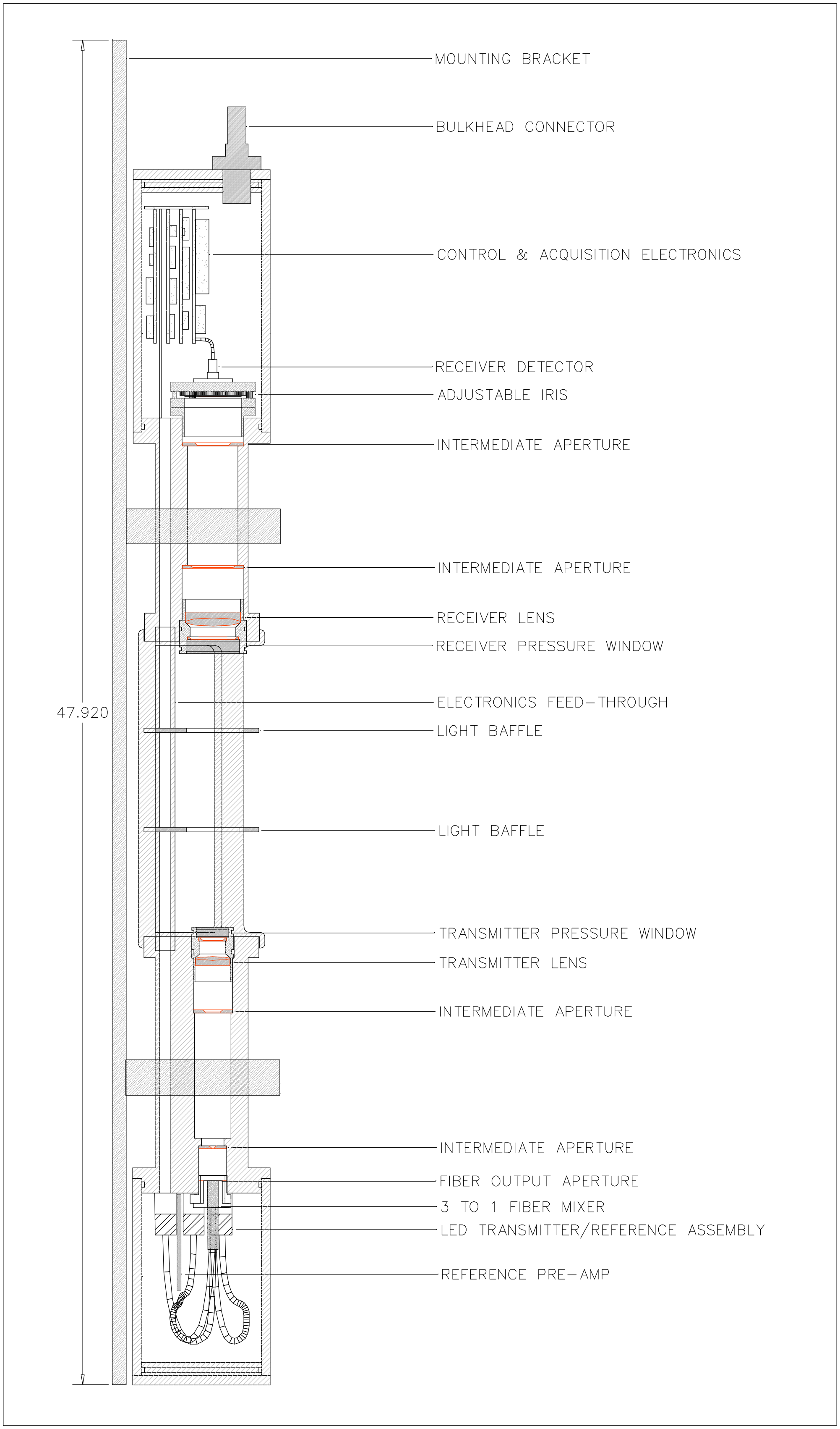
MOUNTING BRACKET
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ADJUSTABLE IRIS
INTERMEDIATE APERTURE
INTERMEDIATE APERTURE
RECEIVER LENS
RECEIVER PRESSURE WINDOW
47.920
ELECTRONICS FEED-THROUGH
LIGHT BAFFLE
LIGHT BAFFLE
TRANSMITTER PRESSURE WINDOW
TRANSMITTER LENS
INTERMEDIATE APERTURE
INTERMEDIATE APERTURE
FIBER OUTPUT APERTURE
3 TO 1 FIBER MIXER
LED TRANSMITTER/REFERENCE ASSEMBLY
REFERENCE PRE-AMP

The primary light source consists of three LEDs (light-emitting diodes) representing the three primary wavelengths used in the measurement. The LEDs directly couple into 0.6 mm aperture fiber ends. The three ends are then randomly mixed into a single 1mm output aperture. Mounted coaxially directly behind the LEDs are separate reference detectors measuring fluctuations of light levels due to temperature changes and lamp aging. Light from the fiber output aperture is modulated separately for each wavelength.

The output light is collimated by a 200 mm achromat lens and passes into the sample volume. The receiver assembly collects the directly transmitted portion of the beam as well as light scattered into the near forward direction. This light is focused by another 200 mm lens. A variable aperture iris is located at the focal plane. The aperture is controlled via a stepper motor which provides approximately 0.05 degree/step resolution. Directly behind the iris a large area diffuser plate and detector collecting the light.

The controller scans through wavelengths and aperture diameter in accordance with programmed sequencing. Transmittance values get measured at each setting. A complete scan translates into an angular range spanning from approximately 0.13 degrees to 2.5 degrees. The minimum effective angle of measurement is determined by the effective collimation limits of the system. The outer range is defined by the size of the beam waist, the 250 mm optical path and the collection aperture of the receiver. With subsequent correction for scattering losses on the outer diameter of the beam waist, the range can be expanded to approximately 4.5 degrees. From these transmittance values the system attenuation coefficient for a given acceptance angle may be directly derived and the Volume Scattering Function may be subsequently derived (Moore,1995).

The light sources and the receiver are synchronously modulated in order to reject ambient light and improve signal to noise ratios of the measurements. Subsequently the unit requires no flow-through module. However windows for the unit are designed to accommodate a flow cell when engaged in bench top laboratory operations.

The control and acquisition electronics consist of four primary circuit boards connected to a primary backplane. The individual boards consists of a power IO interface board, a processor/memory board, an analog interface board and an interface board for IO signals going to various components within the instrument.

In designing the unit, consideration was given to creating a mechanically stable platform for the instrument. Innovations applied towards this end include the multi-wavelength solid state light source, the massive primary transmitter and receiver mounts, the unistrut spacer assembly and the separate mounting bracket attached to the instrument.

IMPACT/APPLICATIONS

The advent of widespread remote sensing of our oceans requires a companion set of tools for fundamental optical characterization of the water. While the scope of remote sensing now ranges from determining global ocean biomass concentrations, to fisheries monitoring, to anti-mine

warfare, the fundamental objective is to see and identify specific features within the water. Without effective attenuation, absorption and scattering measurements, researchers and image analysts have limited ability to extract information about these features from the background medium. The VABAM is a tool which will provide an attenuation measurement with an angular acceptance that can be matched to specific applications. It will define the shape of the scattering function in the very near forward direction which is critical to analysis of image visibility problems. Moreover it will supply the information as a function of wavelength.

The data and results derived from this instrument should find widespread use in numerous major research programs and operational applications incorporating remote sensing platforms which require *in situ* validation and correction.

TRANSITIONS

The VABAM will be turned over to researchers at NRL for primary field validation work. It will be deployed with our Intermediate and Large Angle Scattering Sensor (ILASS) and our Modular Ocean Data and Power System (MODAPS). Once the validation work is complete and any needed modifications upon the instrument are completed, the instrument will be made available to researchers for evaluation and subsequent operational use. WET Labs is employing the sensor technology developed during this project towards several commercial applications.

RELATED PROJECTS

WET Labs is engaged in the development of an Intermediate and Large Angle Scattering Sensor for determination of the volume scattering function for the range of scattering angles from 60 to 165 degrees.

REFERENCES

Moore, C. 1995: Variable aperture beam attenuation meter. Environmental Optics Abstract Book FY 1995, ONR 32296-7: 219-229.